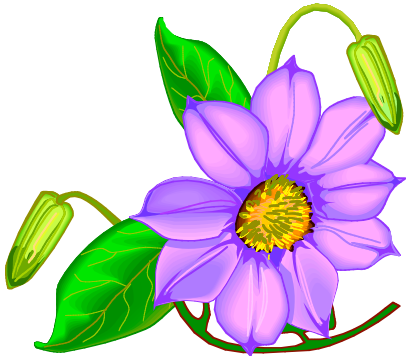
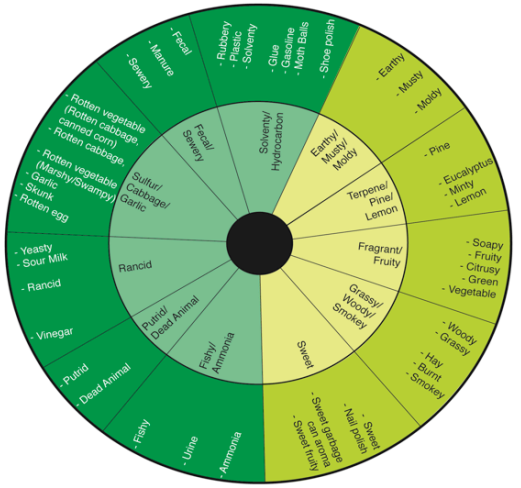


Odor Wheel Applications



Mel Suffet

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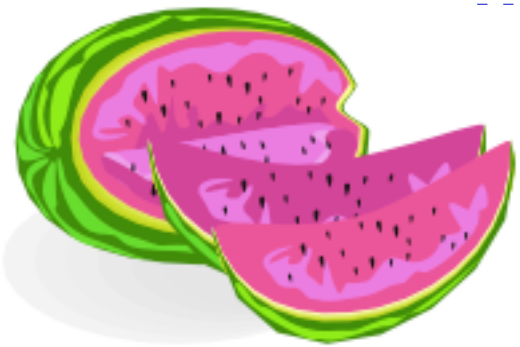
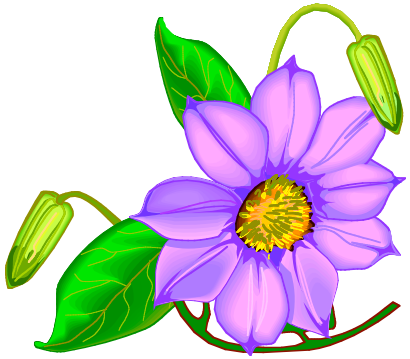


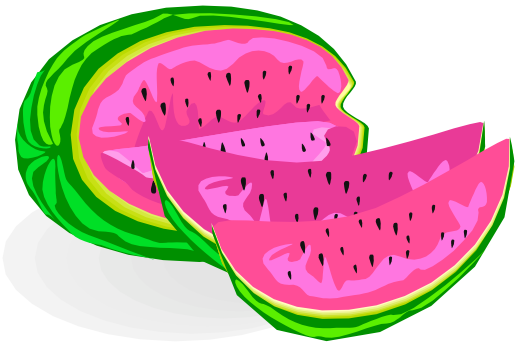


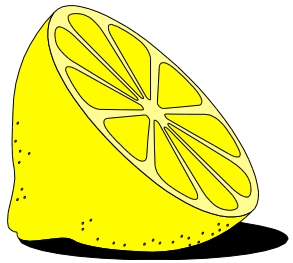
Character of Odor

Naming the Odor, so that Everyone Understands the Problem.

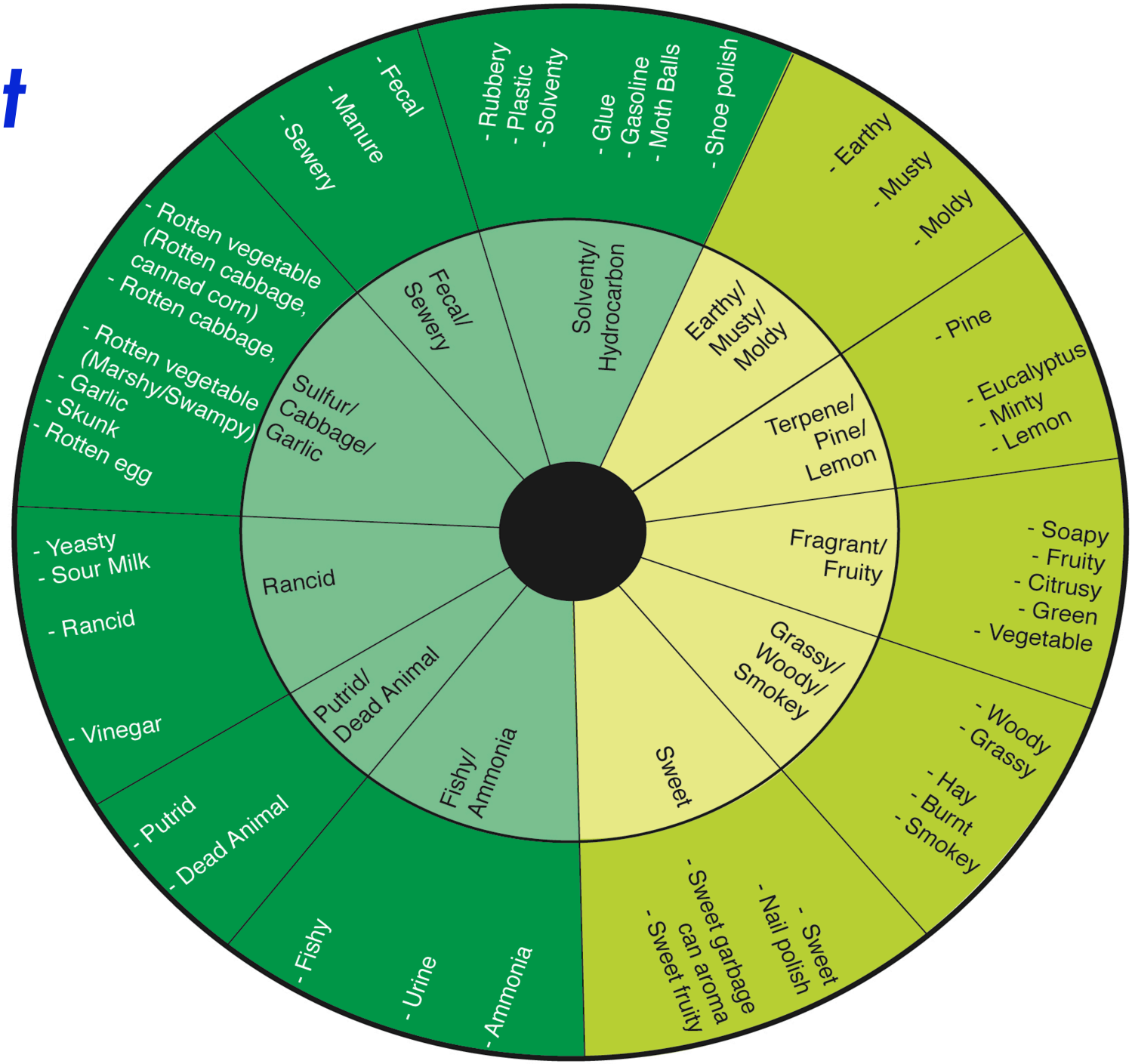
-Critical to Understanding Odor Nuisance

-Naming Consensus Between Panelists and the Public

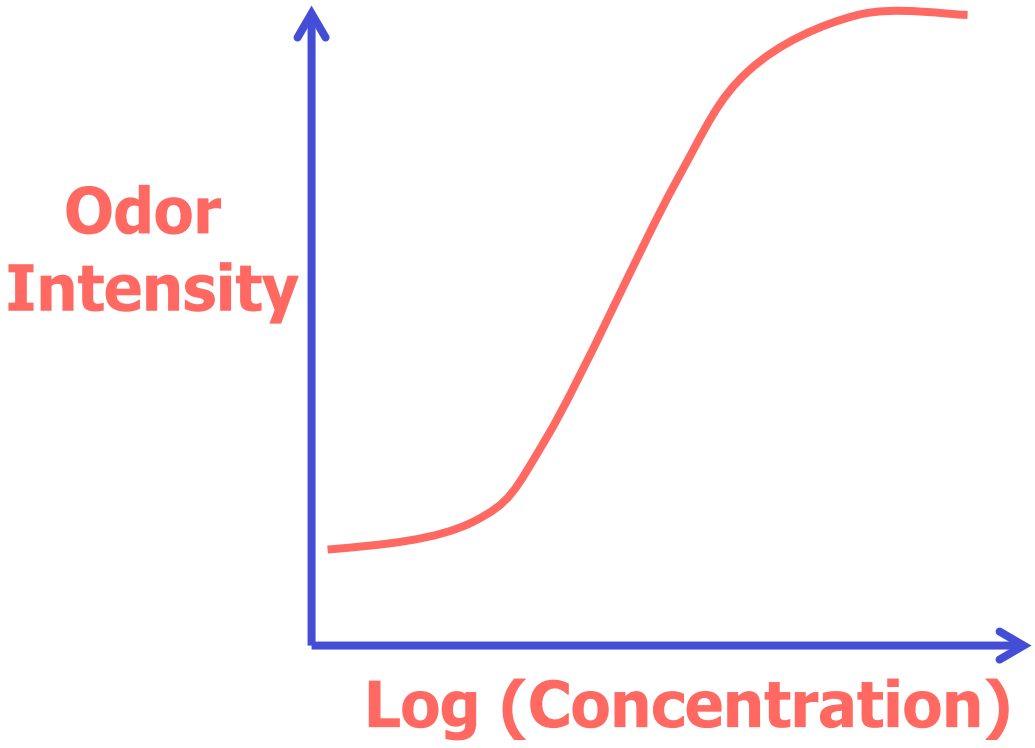




Compost Odor Wheel



EACH Odorant Concentration versus Odor Intensity



Odor Intensity =

m Log [conc.] + b

Weber-Fechner Law

Log (Odor Intensity) =

m Log [conc.] + b

Steven's Power Law

- Semi-logarithmic relationship
- Different chemicals have different curves

RELEASING ODORANTS INTO AIR

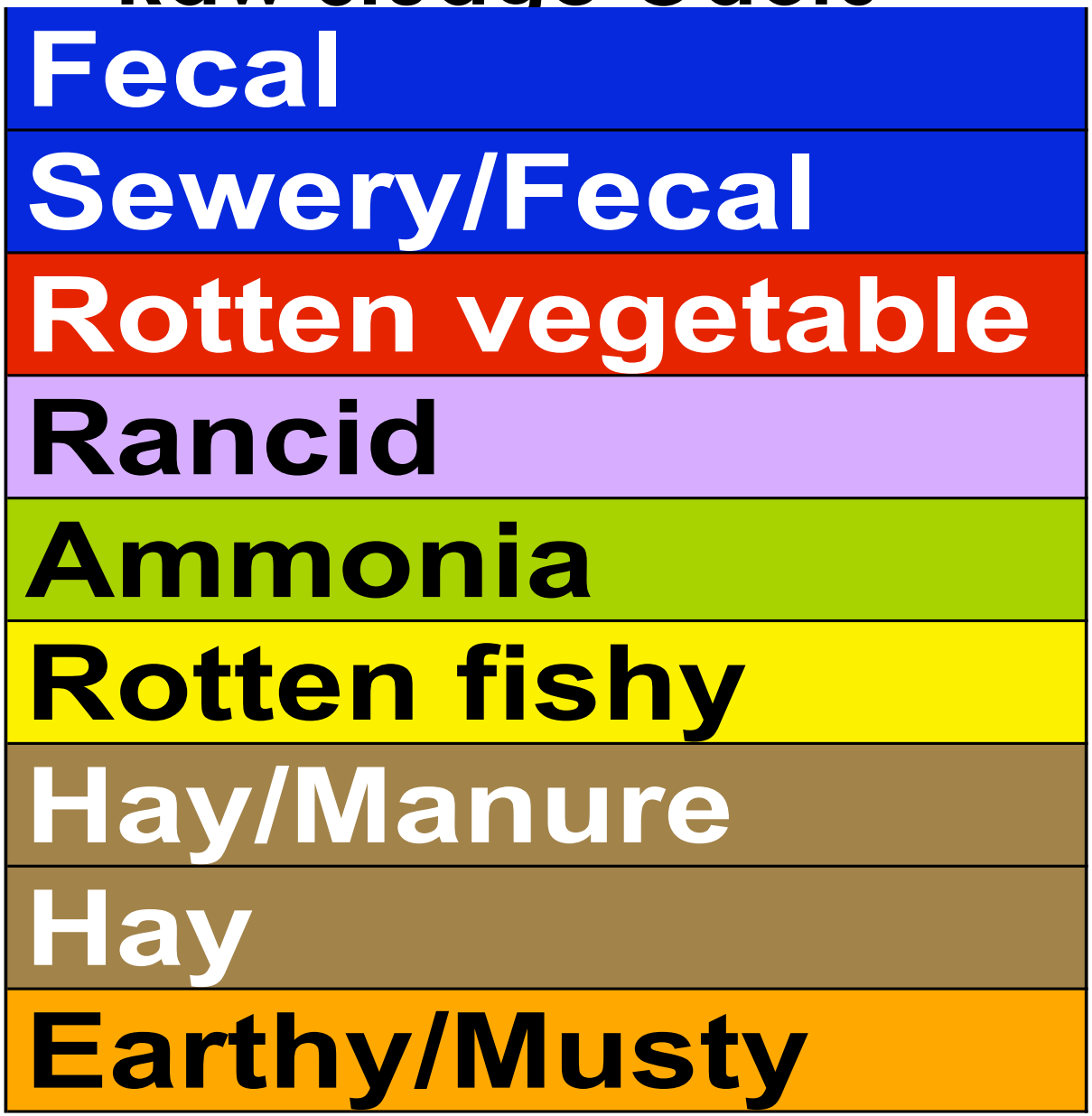
Case Study 1.Compost Treatment of Raw Sludge from a WWTP

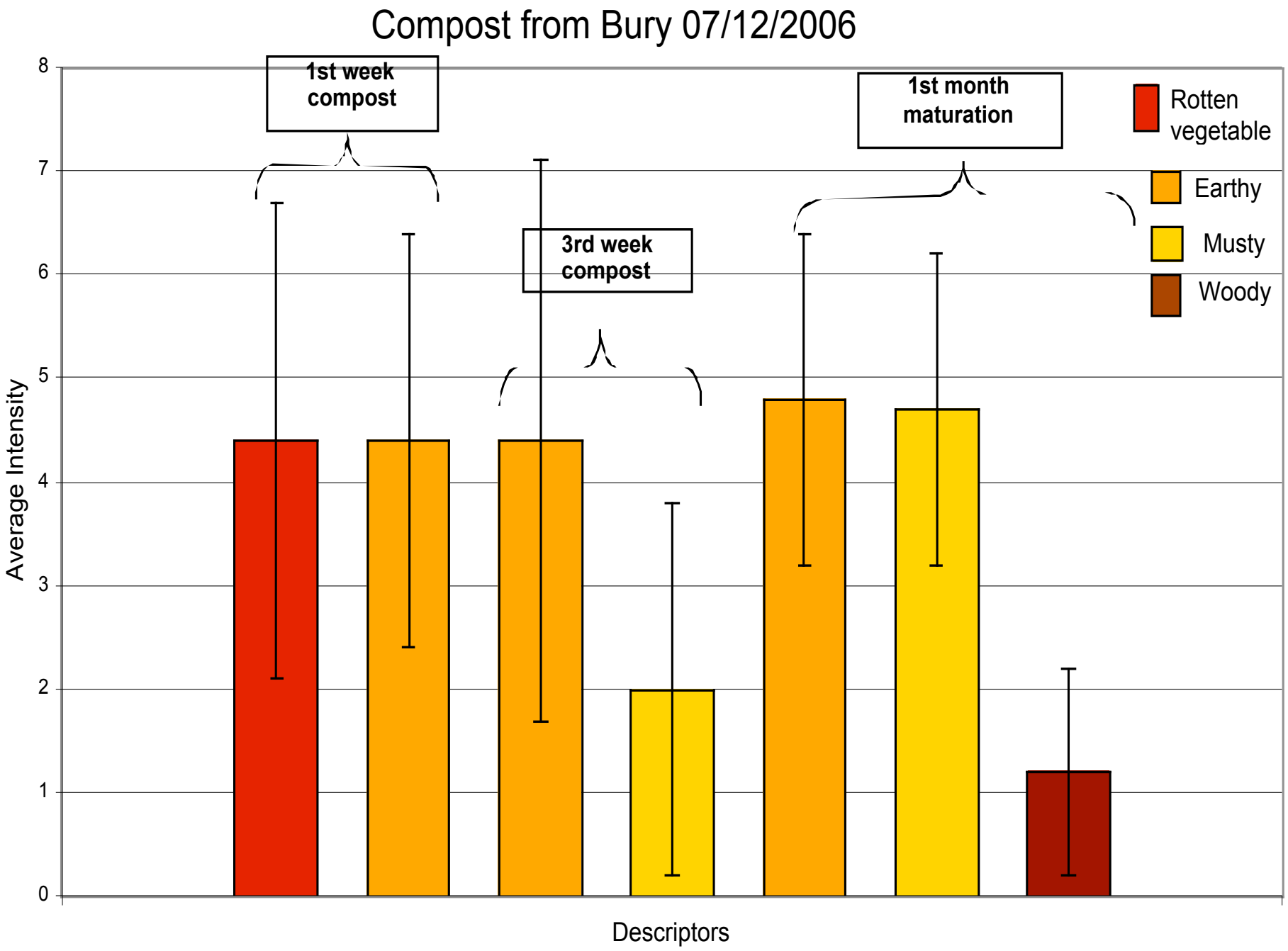
Sludge A	Avg.	S.D.
Hay/Manure	3.5	3
Sewery/Fecal	2.5	2.2
Ammonia	1.5	0.9
Earthy	1.5	1.7
Rotten vegetable	1.3	1.6
Burnt	note	

Sludge B	Avg.	S.D.
Ammonia	7.5	0.9
Earthy	2	2
Rotten fishy	1.5	1.7
Dead animal	note	
Hay	note	

Sludge C	Avg.	S.D.
Fecal	5.5	0.9
Hay	3	2.2
Rancid	2	2.4
Ammonia	1.3	1.6
Earthy	note	
Rotten vegetable	note	

Raw Sludge Odors




Compost from Bury 07/12/2006
1st week compost
3rd week compost
1st month maturation
Rotten vegetable
Earthy
Musty
Woody
Average Intensity
0
1
2
3
4
5
6
7
8
Descriptors

Case Study 2. 4/28/06
Biofilter Results

Biofilter In	Avg.	S.D.
Cabbage	6	2.4
Fish	5	3.3
Sewery	note	
Acid	note	
Earthy	note	

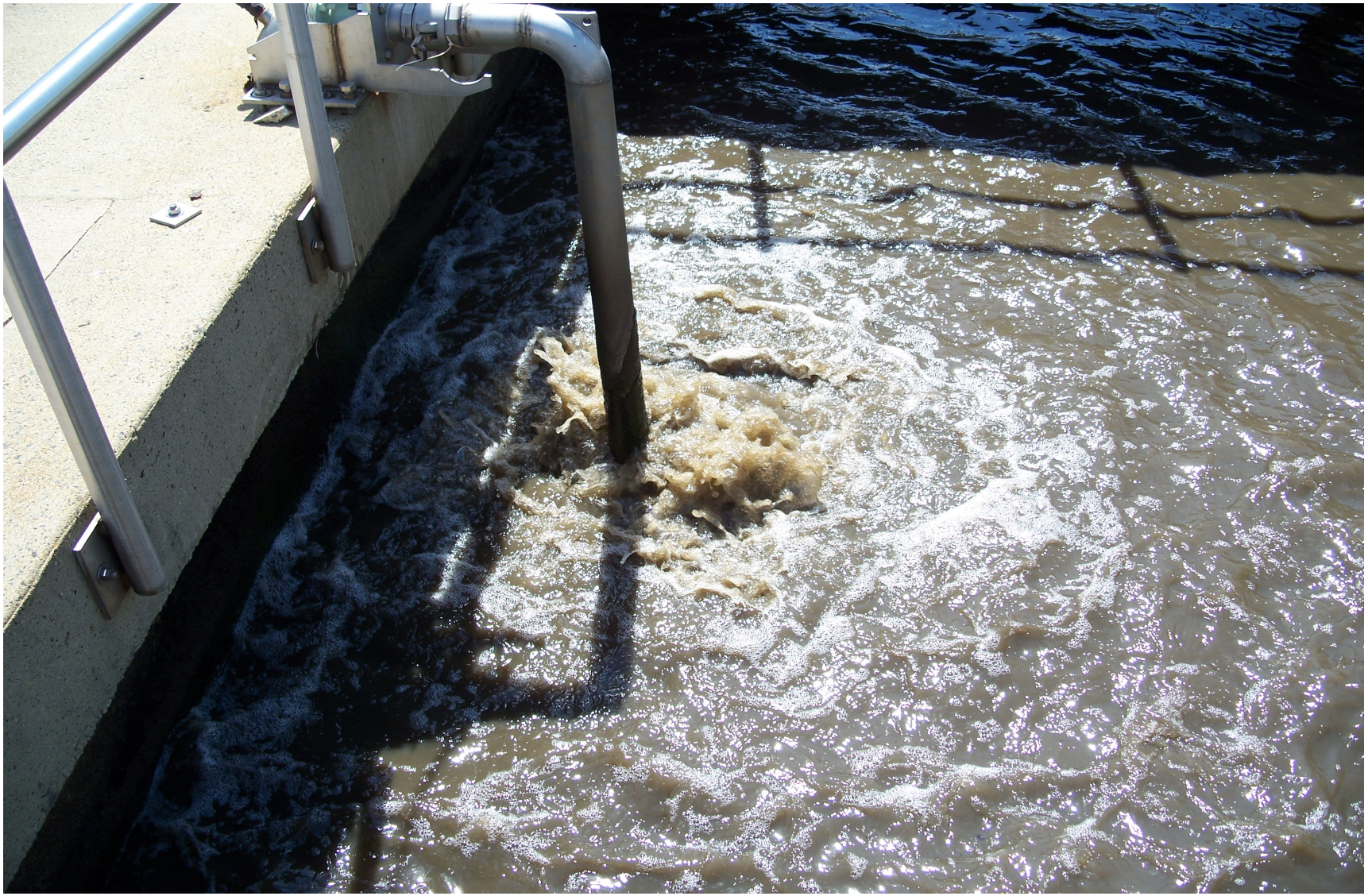
Biofilter Out	Avg.	S.D.
Cabbage	3	3
Fish	1.5	1.7
Rancid	note	
Fecal	note	
Oxidant	note	
Pine	note	

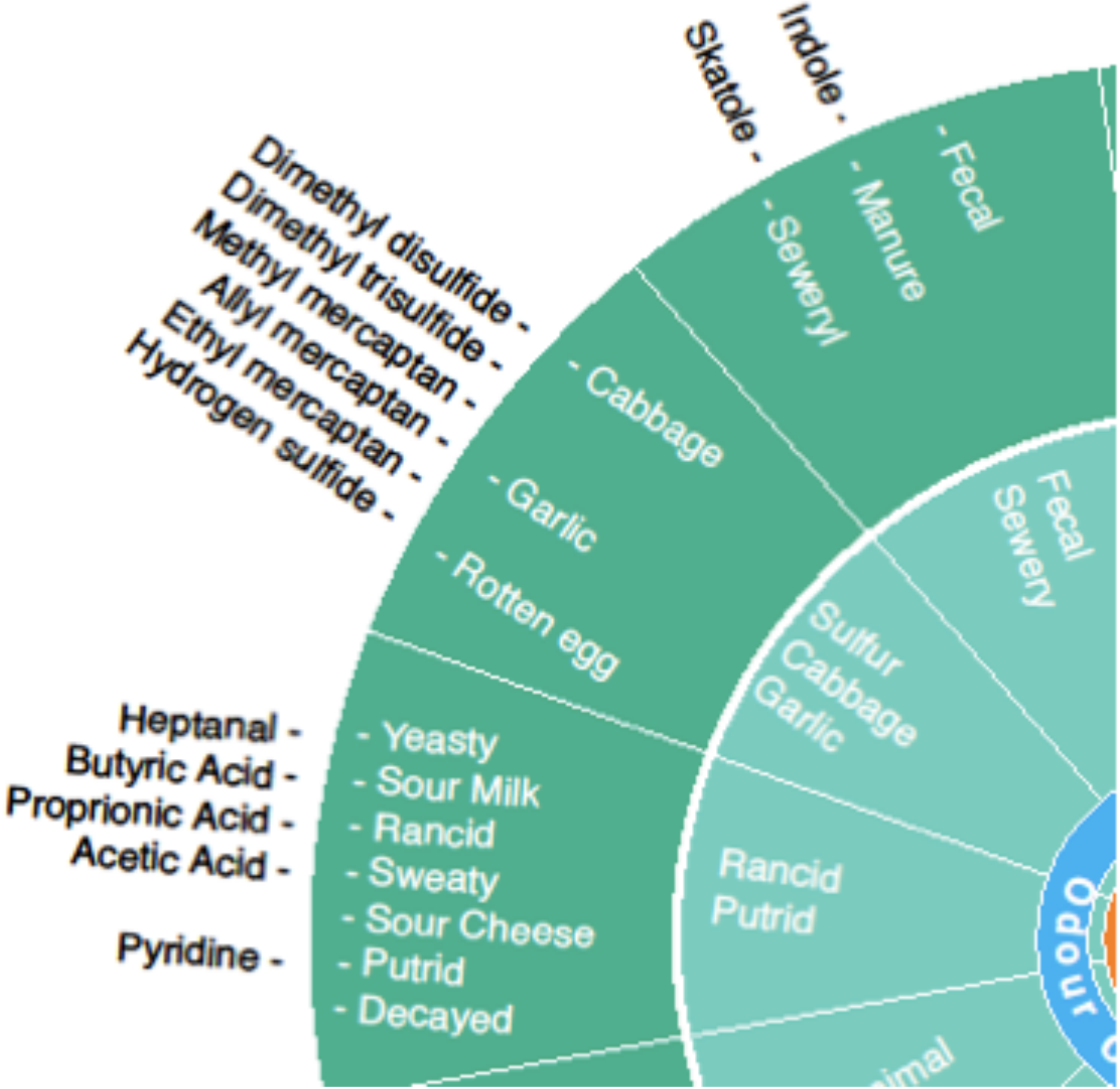
Note: Basis of quantification - H2S

Case 3. Odors-Biological WW Treatment

Odor Type (60 samples/yr)	Times used in Consensus Year 1	Year 2
oniony	60	38
garlicky	29	18
dec.vegetation	29	39
earthy	20	42
briny	19	2
musty	15	8
solventy	12	14
creeky	11	20
6 others	<10 identifications	

Aerated activated sludge is one source of odors




Indole -
Skatole -
Dimethyl disulfide -
Dimethyl trisulfide -
Methyl mercaptan -
Allyl mercaptan -
Ethyl mercaptan -
Hydrogen sulfide -
Heptanal -
Butyric Acid -
Proprionic Acid -
Acetic Acid -
Pyridine -
- Fecal
- Manure
- Sewery
- Cabbage
- Garlic
- Rotten egg
- Yeasty
- Sour Milk
- Rancid
- Sweaty
- Sour Cheese
- Putrid
- Decayed
Fecal
Sewery
Sulfur
Cabbage
Garlic
Rancid
Putrid
Odour

Case Study 3- 2001-5

- Odor surveys in the community at one wastewater plant had identified a particular persistent odor
- The odor team described it as "canned corn" (rotten cabbage) in odor quality
- The odor team agreed that is smelled just like an odor standard of dimethyl sulfide
- MICROBIOLOGICALLY:
- $R\text{-}O\text{-}CH_3 + H_2S \rightarrow R\text{-}OH + CH_3SH$
- $R\text{-}O\text{-}CH_3 + CH_3SH \rightarrow R\text{-}OH + CH_3SCH_3$
- $CH_3SH + CH_3SH + O_2 \rightarrow H_2O + CH_3SSCH_3$

Typical Levels of DMS in 2004/ 2005 at the WWT Plant

Location	Oct – Nov 2003 (avg)	April 2004	Aug – Sept 2004 (3 washes from R&H)	May (avg) 2005 (uniform discharges)
R&H	----	9-63	ND – 706	47
PST #1 In	----	12-176	35 – 5980	457
PST #1 Out	----	16-149	50 – 4800	520
PST #2 Out	----	----	----	487
Aeration Tanks	561 (ppb)	11-215	15 – 1510	72, 164
RAS	----	15-98	74 – 3200	441
Plant Effluent	----	----	----	ND

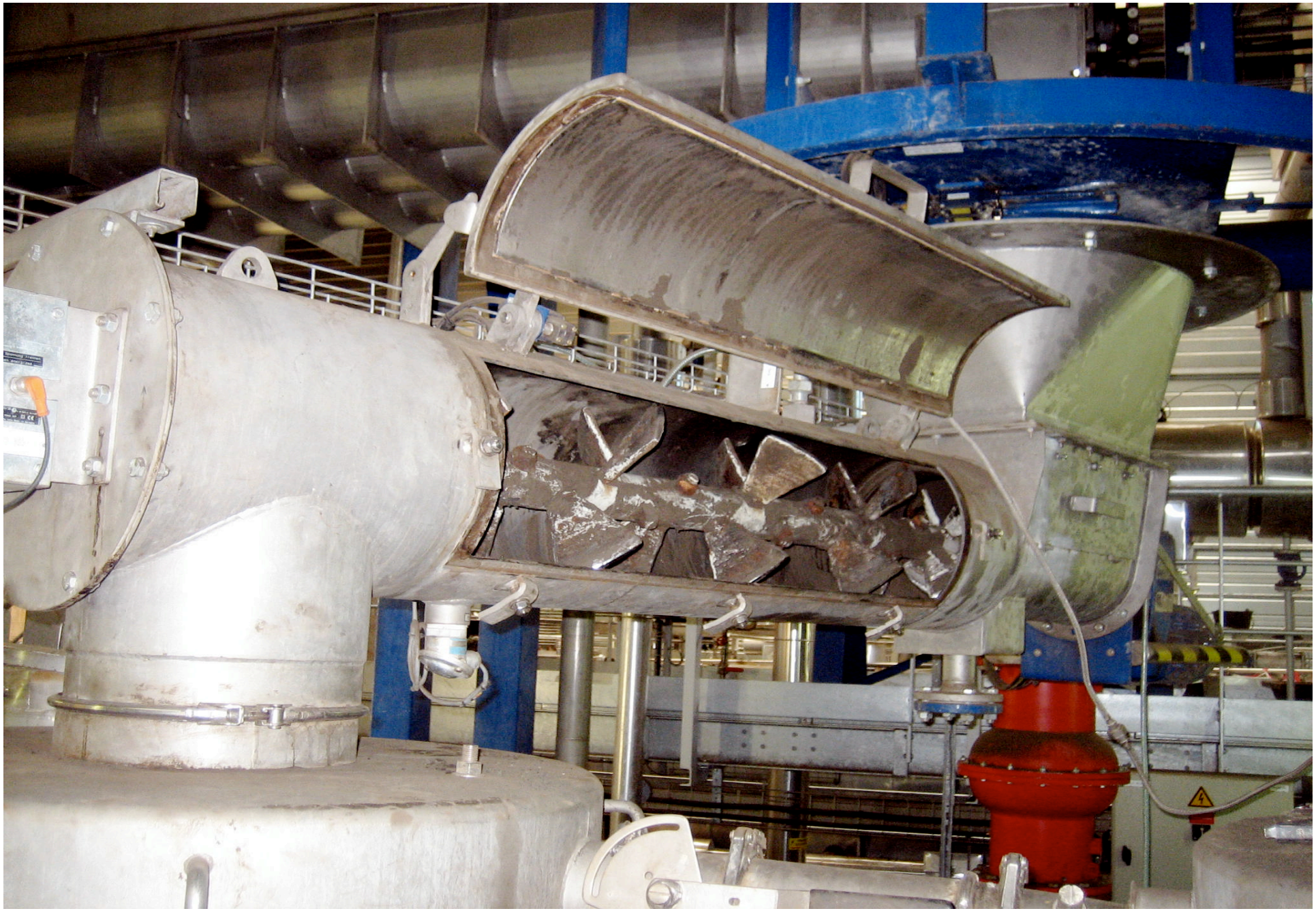
Dimethyl Sulfide (DMS)

- DMS was unusually high compared to methyl mercaptan and dimethyl trisufide
- An industrial source in the sewer collection system was tracked down
- The industry was discharging dimethyl sulfoxide (DMSO)
- Microbiologically DMSO → DMS

Dimethyl Sulfoxide (DMSO)

- Studies were conducted in cooperation with the industrial source to reduce discharges of the DMSO
- DMSO below levels of 400 µg/L have reduced the DMS to about 50 µg/L or less, and the "canned corn" (rotten cabbage) DMS odor has not been a problem

Case Study 4. Sludge Drying Odors



STEP 1.CLASSIFYING ODOR CATEGORIES

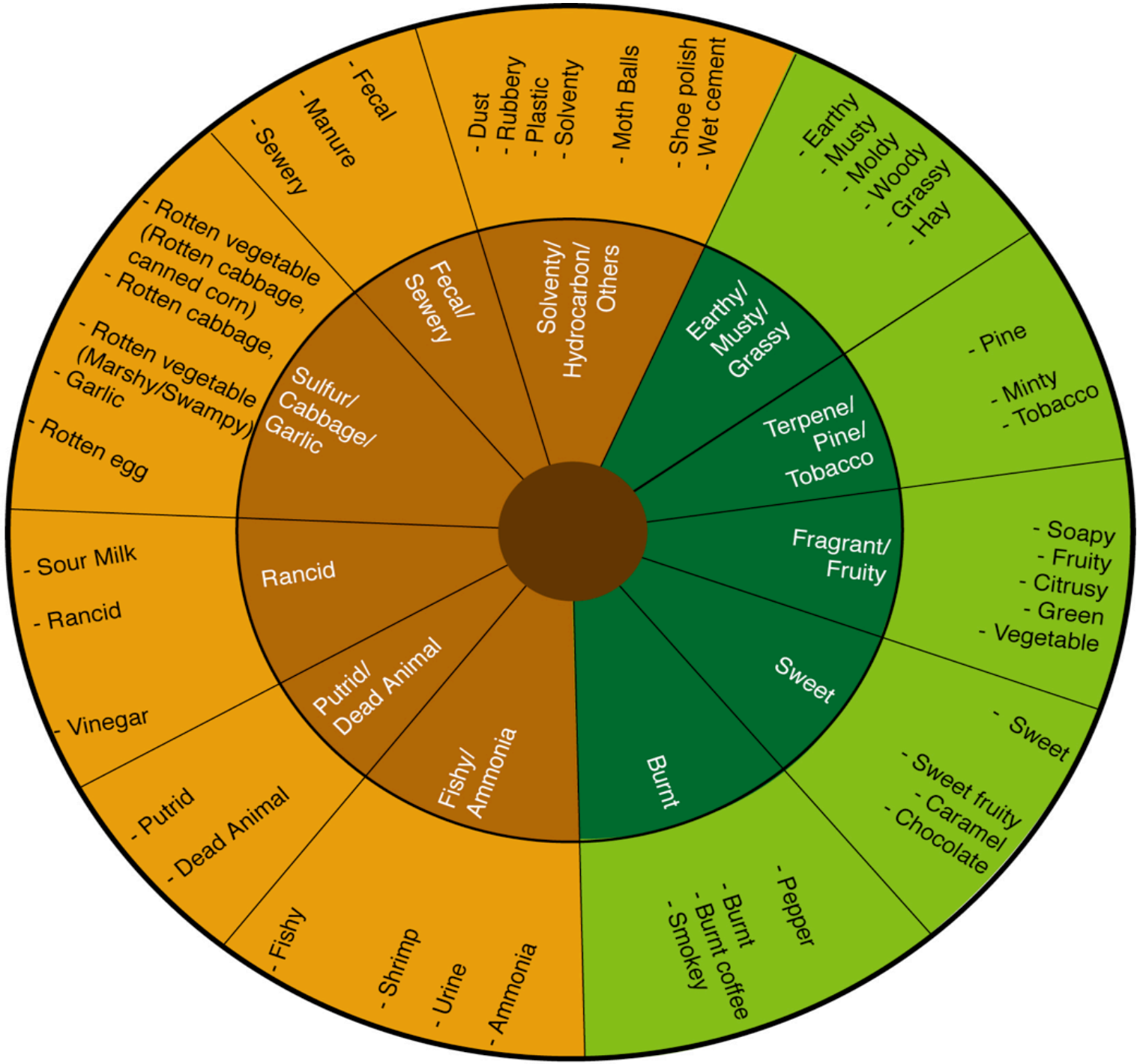
33 dried sludge samples at different stages of treatment plus samples generated by a lab sludge drying pilot

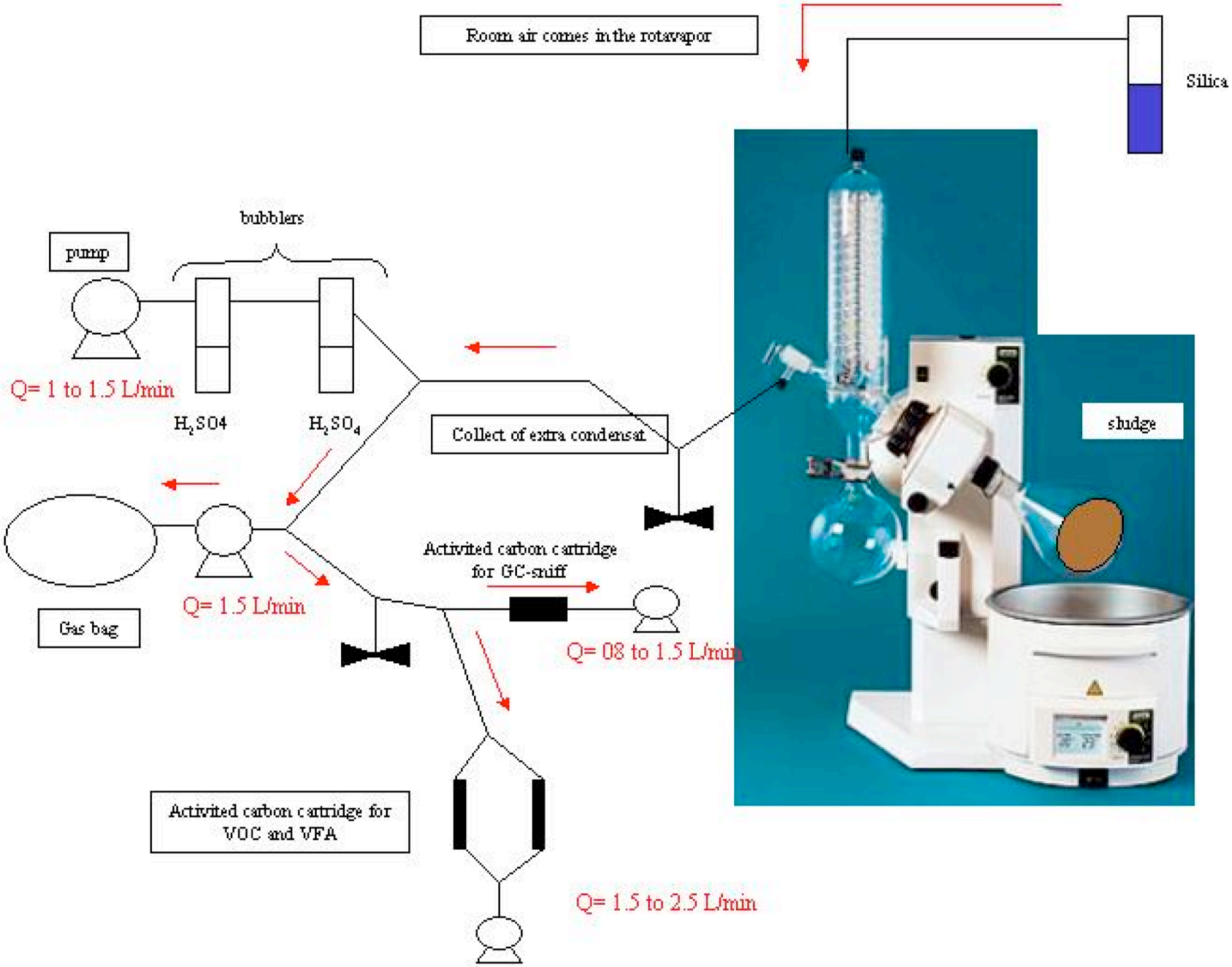
SAMPLE 11		
	Avg.	S.D.
Fecal	4,2	3,6
Earthy	2,9	2,7
Fishy	2,8	3,3
Ammonia	2,4	2,2
Manure	note	
Dead animal	note	
Rancid	note	
Bunt coffee	note	
Rotten cabbage	note	

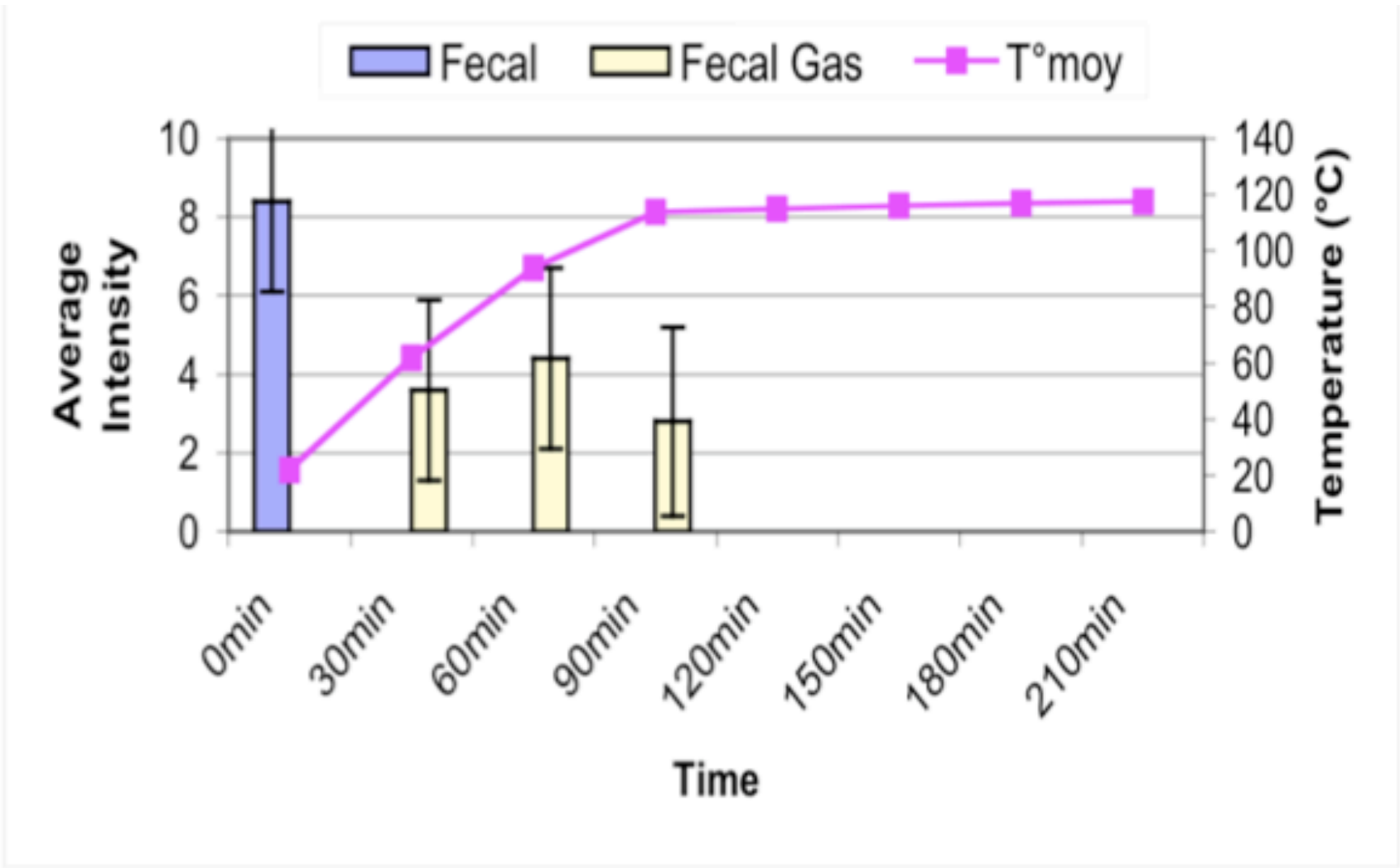
Table 1. Example of a OPM Results for a Sludge Dried Sample

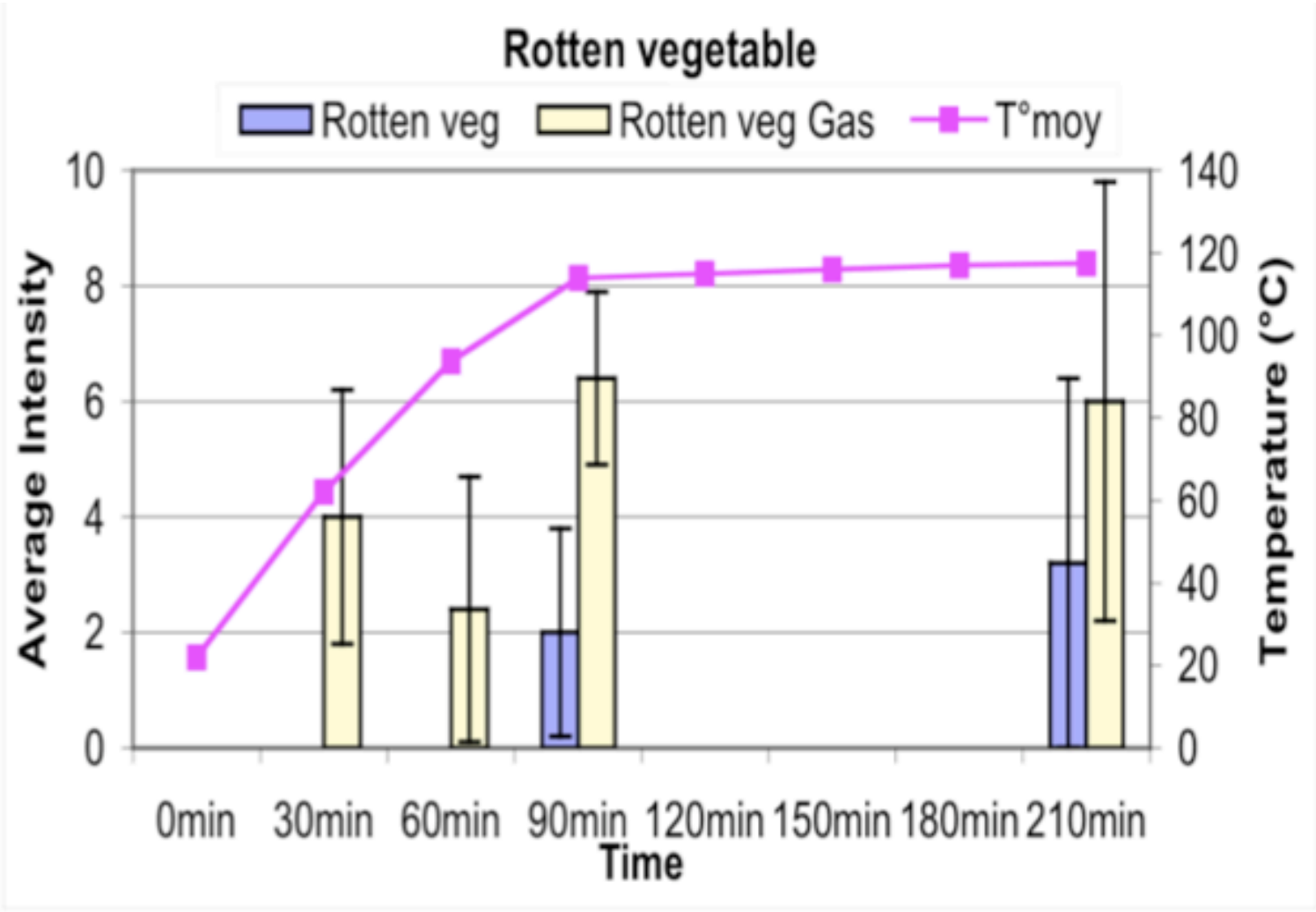
Odor	Total samples	Number of samples with the odor	Intensity Avg.[a]
Rotten fishy	33	30	4.1
Manure/Hay	33	28	3.6
Earthy/Musty	33	29	2.4
Rancid	33	19	2.2
Shrimp	33	8	2.2
Fecal	33	28	2
Sweet	33	3	1.9
Burnt coffee	33	4	1.9
Ammonia	33	21	1.8
Burnt	33	15	1.6
Rotten vegetable	33	5	1.5
Dead Animal	33	5	1.2
Sewery	33	5	1.1

Sludge Drying Odor Wheel

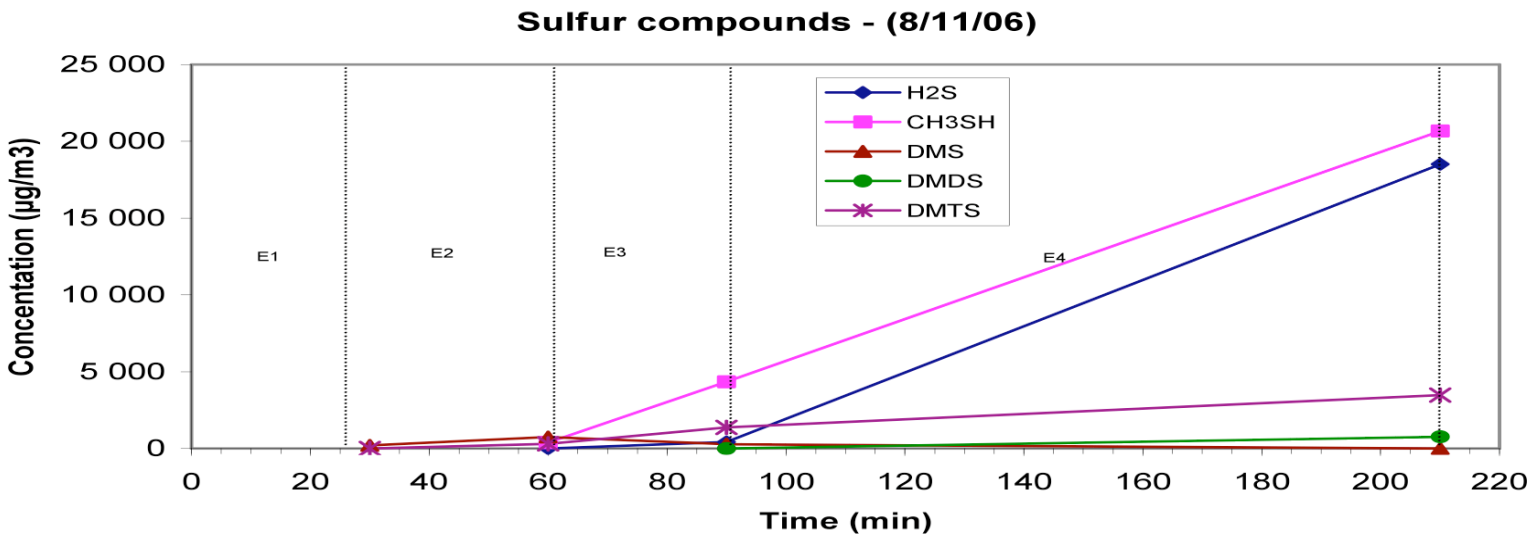


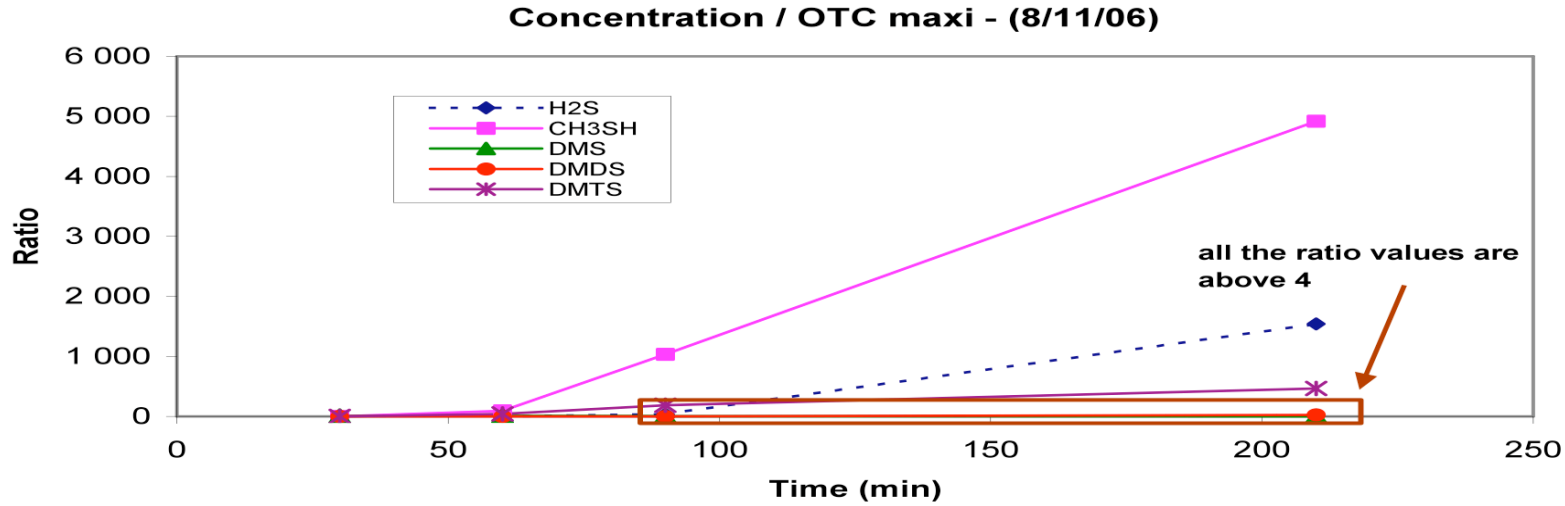

Room air comes in the rotavapor
Silica
bubblers
pump
Q= 1 to 1.5 L/min
H_2SO4
H_2SO_4
Collect of extra condensat
sludge
Activited carbon cartridge for GC-sniff
Q= 1.5 L/min
Gas bag
Q= 08 to 1.5 L/min
Activited carbon cartridge for VOC and VFA
Q= 1.5 to 2.5 L/min

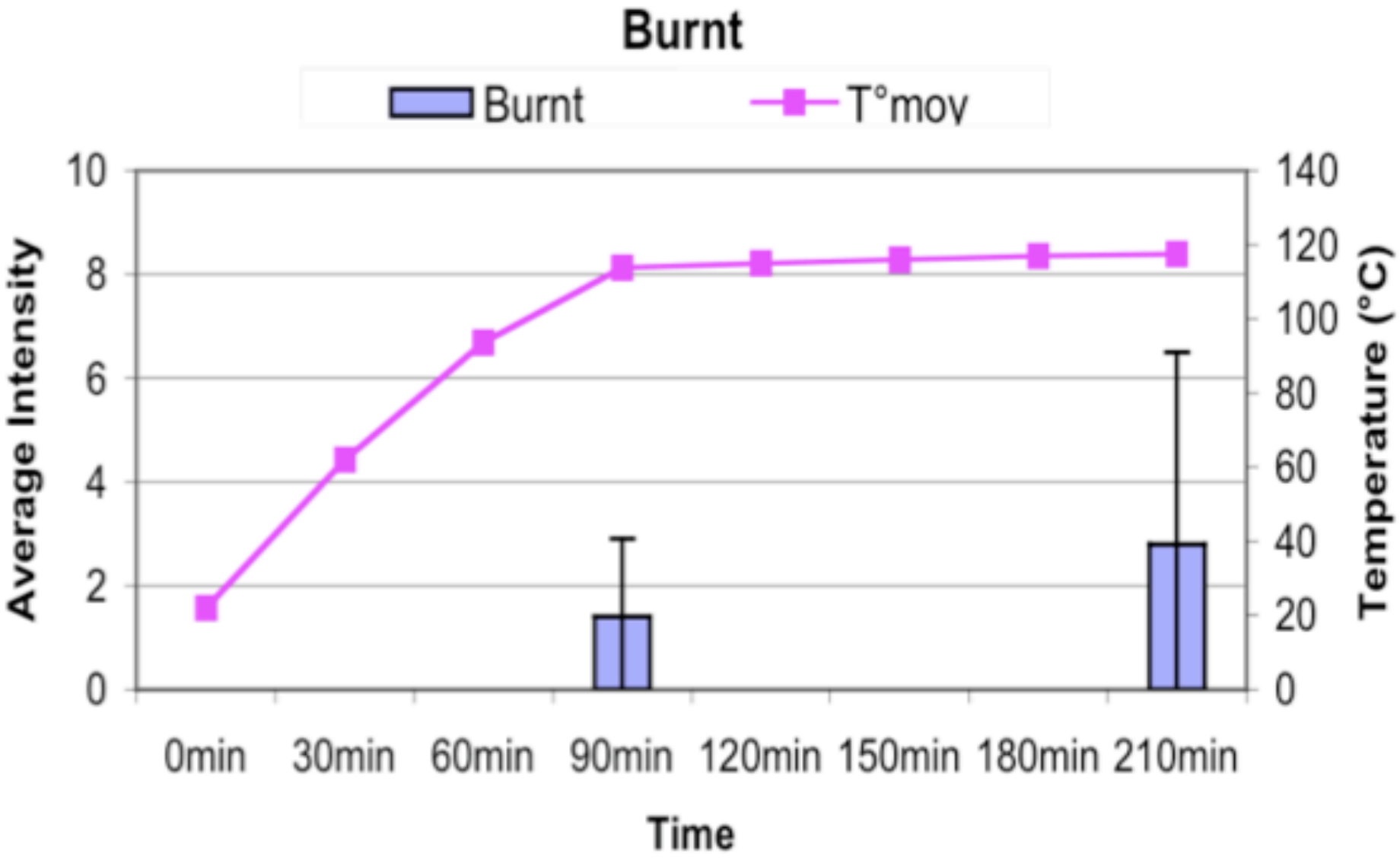

Fecal
Fecal Gas
T°moy
Average Intensity
Temperature (°C)
10
8
6
4
2
0
140
120
100
80
60
40
20
0
0min
30min
60min
90min
120min
150min
180min
210min
Time


Rotten vegetable
Rotten veg
Rotten veg Gas
T°moy
Average Intensity
Temperature (°C)
10
8
6
4
2
0
140
120
100
80
60
40
20
0
0min
30min
60min
90min
120min
150min
180min
210min
Time

STEP 2. PHYSICO-CHEMICAL ANALYSIS





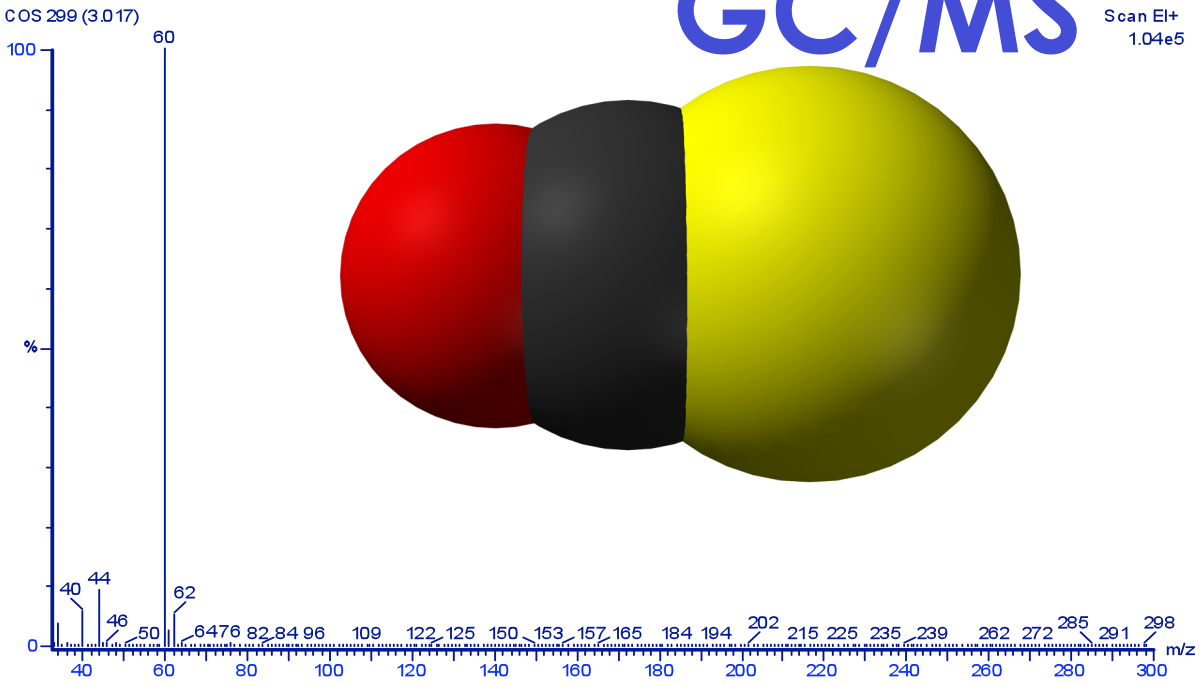

Burnt
Burnt
T°moy
Average Intensity
Temperature (°C)
10
8
6
4
2
0
140
120
100
80
60
40
20
0
0min
30min
60min
90min
120min
150min
180min
210min
Time

STEP 3. CONFIRMATION OF ODORANTS BY OLFACTORY-GC/MS

Correspondence between odour descriptors and specific chemicals as determined by olfactory-GC/MS (sample 2)

Retention time (min)	Odour at olfactory port	Compound identified
3.37	Burnt-Rotten egg	Carbonyl sulphide (COS)
8.39	Vinegar	Acetic acid
9.38	Rotten cabbage- garlic	Dimethyldisulfide
17.20	Rancid	Butyric acid

STEP 3. CONFIRMATION OF ODORANTS BY OLFACTORY-GC/MS

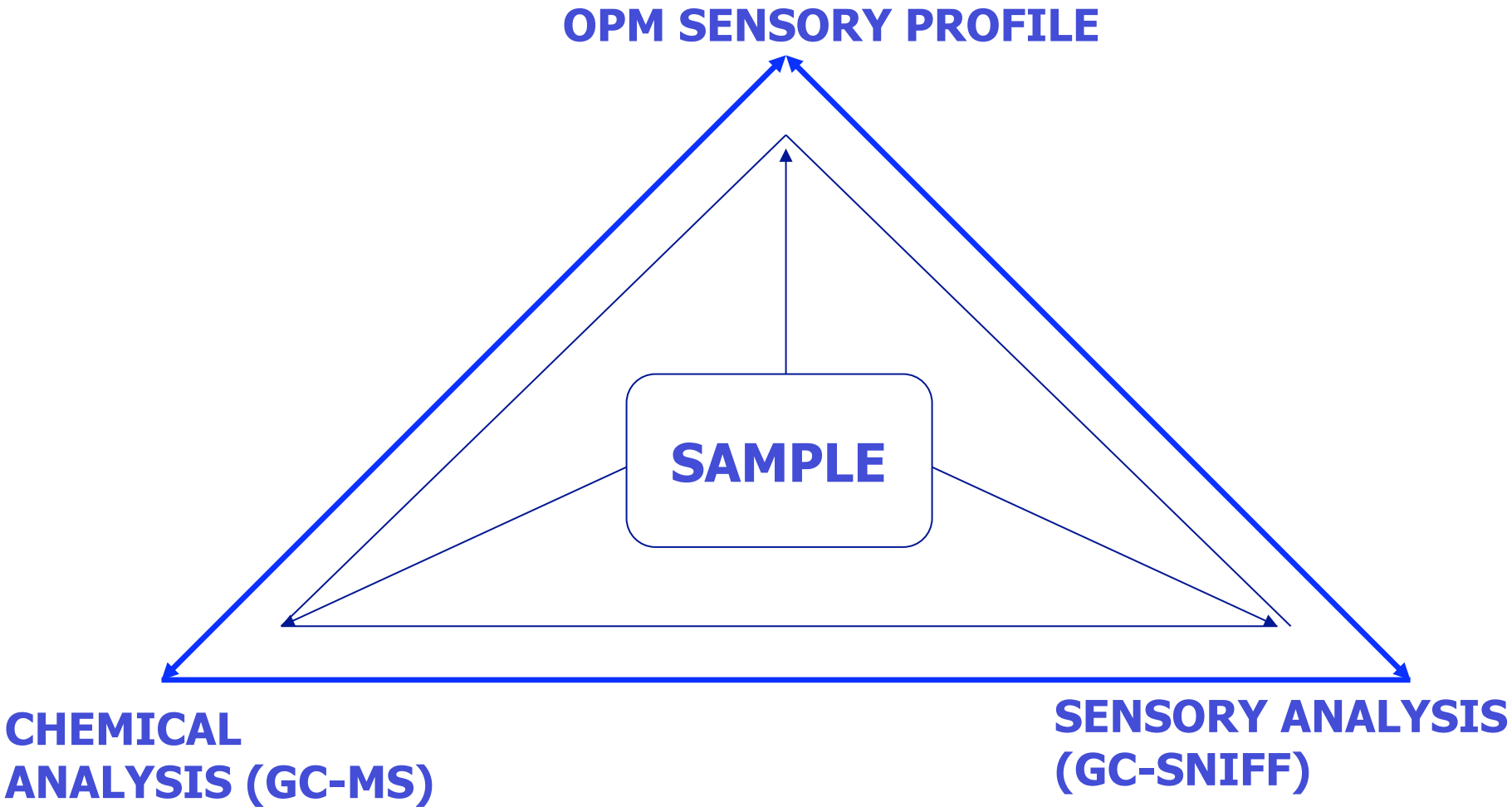


-Can form from the reaction of sulfur with C=O

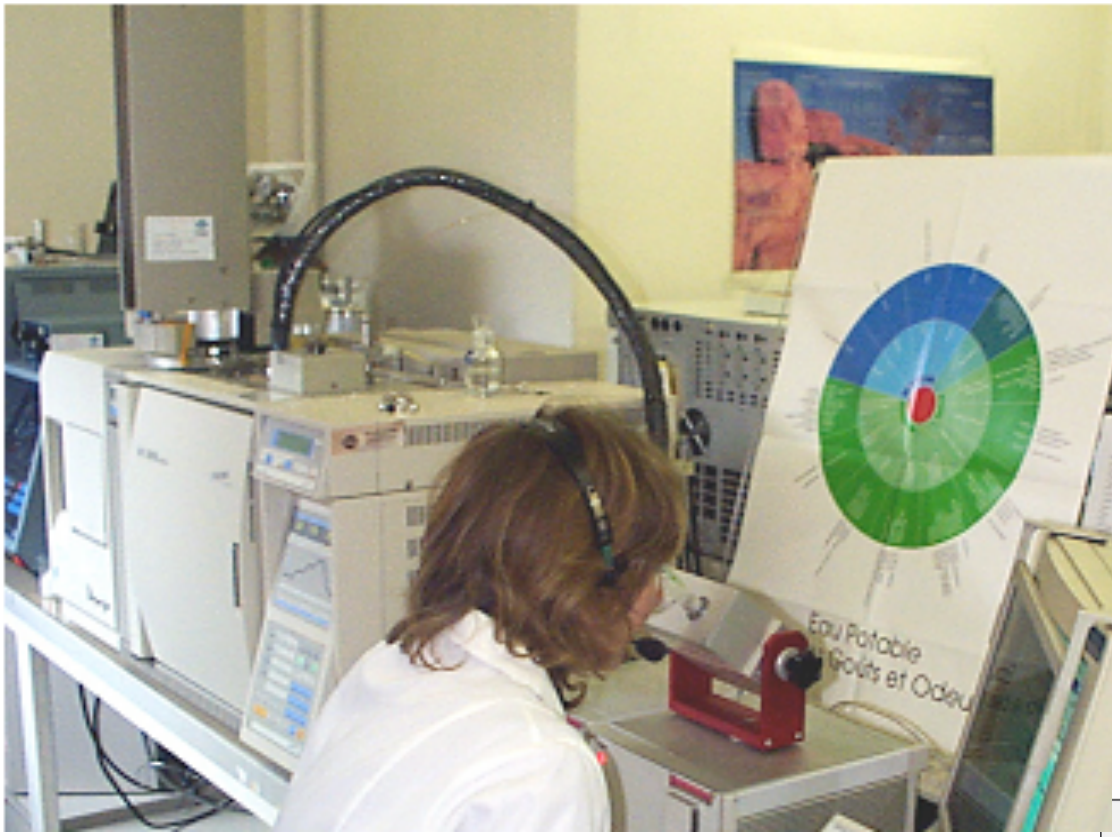
-Also present in foodstuffs.

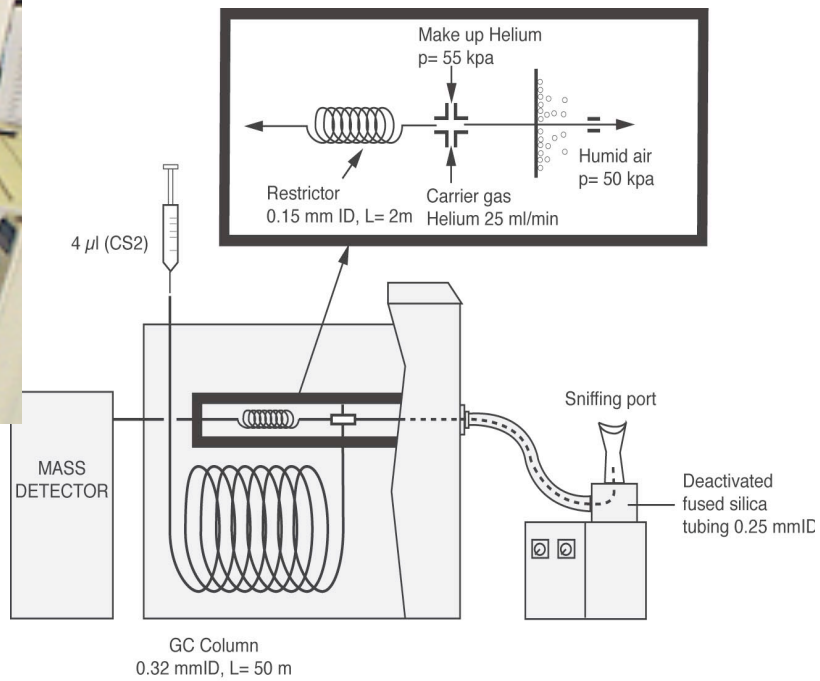
Mass spectrum of carbonyl sulfide (O=C=S)

CONFIRMATORY ANALYSIS



CONFIRMATION OF ODORANTS BY OLFACTORY-GC/MS





Conclusions

- The **human nose** continues to be the most sensitive and quickest way to measure odor.
- The "**odor wheel**" represents an excellent tool to represent the character of the odor
- The "**odor intensity**" is found from the W-F curve
- The **Odor Profile Method** determines the Odor Character and Intensity by an Odor Panel
- **Chemical analysis** is used to backstop OPM.